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Control of Toxic Emissions from the Thermal Treatment of Contaminated Soils

Radian Corp., Sacramento, CA

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CONTROL OF TOXIC EMISSIONS FROM THE THERMAL TREATMENT OF CONTAMINATED SOILS

by

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16. ABSTRACT

The U.S. Environmental Protection Agency (EPA) is investigating technologies to clean up hazardous waste sites through the Superfund Innovative Technology Evaluation (SITE) Program. Two sites having PCBs and heavy metals were demonstrated using the Shirco Infrared System a roasting process. These locations were at Peak Oil, Brandon Florida and Rose Township, Michigan. Average values of contaminants in the material being thermally treated for decontamination are given as well as average values of emissions to the air, wastewater analysis and decontaminated soil analyses.

Complete detailed reports are being completed on these operations and are expected to be released to the public before 1989 by the U.S. EPA.

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NOTICE

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

The U.S. Environmental Protection Agency (EPA) is investigating innovative technologies to clean up hazardous waste sites through the Superfund Innovative Technologies Evaluation (SITE) program. Two sites that were designated for inclusion in the SITE program had PCB-contaminated soil but also had high levels of toxic metals, particularly lead. These sites were the Peak Oil site in Brandon, Florida and the Demode Road, Rose Township site near Flint, Michigan.

The innovative technology to be used at these sites was thermal destruction of the PCBs in the soil with particular attention paid to control of the emissions, especially lead. At both sites, Shirco Infrared Systems, Inc. (now a division of ECOVA) provided the mobile incinerator and Radian Corporation provided the sampling and analytical support; the sites were managed by Enviresponse, Inc. Both sites were tested in 1987.

At the time of this presentation (August, 1988) the complete reports and the summary report were in draft form and being reviewed by EPA. Therefore, the information presented in this talk must be viewed as preliminary, but the data are not expected to change. There are voluminous quantities of data--far too much to include in this report--and it has been reduced to average values rather than keeping the specifics of each run and each

test. Greater detail will be given in the final report, which is expected to be issued later this year. The average data used in this talk is believed to be indicative of the full data.

The purpose of this presentation is to get the general information out promptly and to inform interested readers about the nature of the work; if greater detail is needed, they should acquire a copy of the final report (when available through RREL in Cincinnati).

Since the data rather speak for themselves and in the desire to present the results as quickly as possible, no formal paper suitable for submission is available at this time. Rather, only copies of the slides presented at the conference (i.e., the AIChE 1988 Summer National Meeting in Denver, CO, August 21-24) are included in this report.

EPA Superfund Innovative Technology Evaluation (SITE)
Locations:

1. Peak Oil Site, Brandon, Florida

2. Demode Road Site, Rose Township, Oakland County, Michigan (Rose Township Site)

Participants:

Project Sponsor: U.S. EPA, RREL (Cincinnati, OH)
SITE Project Manager: Howard Wall, U.S. EPA, RREL, Cincinnati, OH
Project Manager: Enviresponse, Inc., Livingston, NJ
Incinerator: Shirco Infrared Systems, Inc., Dallas, TX
Sampling and Analysis: Radian Corporation, Austin, TX

PROGRAM OBJECTIVES

1. Experimental verification of thermal destruction of PCB contaminated soils to meet all applicable state and federal environmental standards.

2. Determine if metals associated with the contaminated soils would be liberated during incineration process.

3. Measurement of other environmental parameters associated with the handling and incineration of contaminated soils.

4. Determine the process operating conditions required to meet the above objectives and the approximate cost of operation a Larger--scale unit.
   (Note: These data not addressed in this presentation.)

SUMMARY OF PCB DATA

SHIRCO INCINERATOR AT PEAK OIL

Run Number (#)	PCB in Soil Feed (ppm)	PCB in Flue Gas (ug/m3)	PCB DRE Flue Gas (%)	PCB in Ash* (ppm)
1	5.9	0.0082	99.9997	0.007(1%)
2	3.9	0.0220	99.9988	0.240(6%)
3	5.3	0.0070	99.9997	0.900(17%)
4	3.5	0.0138	99.9991	0.540(15%)

*: 1.0 ppm acceptable for disposal

Notes: mono- to deca-chlorobiphenyl Reported.
Most (80-90%) of PCBs were hexa- and hepta-chlorobiphenyls.
Analysis by EPA Method 680 (GC/MS).
No PCBs in Scrubber Solids or Effluent.
Temperature in Primary Chamber = 1600°F.
Temperature in Secondary Chamber = 2200°F.

SUMMARY OF PCB DATA

SHIRCO INCINERATOR AT ROSE TOWNSHIP

Run Number	PCB in Soil Feed	PCB in Flue Gas	PCB DRE Flue Gas	PCB in Ash*
(#)	(ppm)	(ug/m3)	(%)	(ppm)
1	10.2	below DL+	>99.9922	0.037(0.4%)
2	35.2	below DL+	>99.9976	0.112(0.3%)
3	20.4	0.068	99.9953	0.003(0.0%)

*: 1.0 ppm acceptable for disposal.
+: detection limit in flue gas about 0.02 ug/m3.
Notes: mono- to deca-chlorobiphenyl reported.
Predominant PCB was tetrachlorobiphenyl.
Analysis by EPA Method 680 (GC/MS).
No PCBs in Scrubber Solids or Effluent.
Original Survey, PCBs up to 1550 ppm .
Temperature in Primary Chamber = 1600 F.
Temperature in Secondary Chamber = 2200 F,
residence time over 2 seconds.

PCB DESTRUCTION EFFICIENCY VS TEMPERATURE

ROSE TOWNSHIP

Primary Chamber Temp (°F)	Primary Chamber Residence (minutes)	PCB Conc. in soil (ppm)	PCB Conc. in Ash (ppm)	PCB Destruction Efficiency (%)
1600	20	35	0.112	99.68
1600	15	451	0.117	99.97
1600	15	311	0.081	99.98
1600	10	391	0.045	99.99
1200	25	456	0.108	99.98
1200	20	297	0.115	99.96
1200	20	669	0.066	99.99
1200	15	309	0.086	99.98
1200	15	602	0.025	99.99
900	25	367	0.188	99.95
900	20	327	2.079	99.36
900	20	20	3.398	83.19

Soil depth in primary chamber, 1.5 inches.

VOLATILE COMPOUNDS DETECTED AT PEAK OIL SITE
(EPA Method 8240)

Compounds Reported more than once above Detection Limit	Number of times detected			
	Soil Feed (4 runs)	Scrubber (4 runs)	Flue Gas* (9 runs)	Ash (4 runs)
acetone	2	3	NR	4
benzene	4	0	5	4
bromodichloromethane	0	0	3	0
carbon disulfide	2	0	NR	4
chloroform	3	3	5	2
ethyl benzene	4	0	3	0
methylene chloride	4	1	7	4
styrene	1	1	NR	0
toluene	4	0	8	4
1,1,1-trichloroethane	4	0	4	0
trichloroethene	4	0	1	0
trichlorofluoromethane	3	0	4	4
xylene	4	1	NR	0

*: sampled by VOST (Volatile Organic Sampling Train).
NR: not reported
Note:
toluene highest in soil feed (average about 325 ppm).
chloroform highest in flue gas (average about 50,000 ng/m3).
methylene chloride highest in ash (average about 300 ppm).

VOLATILE COMPOUNDS DETECTED AT ROSE TOWNSHIP SITE
(EPA Method 8240)

Compounds Reported more than once above Detection Limit	Number of times detected			
	Soil Feed (3 runs)	Primary Flue Gas (10 runs)	Secondary Flue Gas* (7 runs)	Furnace Ash (3 runs)
acetone	0	7	5	0
acrolein	0	4	1	0
benzene	0	10	7	0
bromomethane	0	8	1	1
2-butanone	0	2	0	0
carbon disulfide	0	3	6	0
carbon tetrachloride	0	3	1	0
chlorobenzene	0	8	2	0
chloroform	0	2	2	0
chloromethane	0	9	3	0
ethyl benzene	0	5	3	0
iodomethane	0	9	3	0
methylene chloride	0	10	7	1
methyl ethyl ketone	0	0	0	2
styrene	0	9	5	0
toluene	0	10	7	0
xylene	0	4	5	0

*: sampled by VOST (Volatile Organic Sampling Train)
Note: only small amounts of benzene and toluene in scrubber.

SEMI-VOLATILE COMPOUNDS DETECTED AT PEAK OIL SITE
(EPA Method 8270)

In Soil Feed Material:	Avg ppm	No. times detected (greater than once)
acenaphthene	15	2 of 4
anthracene	30	2 of 4
2-methylnaphthalene	47	2 of 4
naphthalene	19	2 of 4
In Scrubber Solids:	**ppm**	**No. times detected**
dimethylphthalate	7	4 of 4
In Incinerator Ash:	**ppm**	**No. times detected**
chrysene	5	2 of 4
fluoranthene	4	2 of 4
phenanthrene	6	3 of 4
phenol	3	4 of 4
pyrene	4	3 of 4
In Stack Gas Particulate:	**ng/m3**	**No. times detected**
acetophenone	1,600	2 of 4
diethylphthalate	12,000	4 of 4
dimethylphthalate	1,400	4 of 4
di-n-butylphthalate	11,000	4 of 4
naphthalene	1,300	2 of 4
phenol	1,500	2 of 4

Note: Detection limits mostly between 1.0 and 0.2 ppm

SEMI-VOLATILE COMPOUNDS DETECTED AT ROSE TOWNSHIP
(EPA Method 8270)

In Soil Feed Material:	Avg ppm	No. times detected (greater than once)
none	-	------
In Scrubber Solids:	**ppm**	**No. times detected**
none	-	------
In Incinerator Ash:	**ppm**	**No. times detected**
none	-	------
In Primary Stack Gas:	**ng/m3**	**No. times detected**
benzoic acid	2.5	1 of 2
bis(2-ethylhexyl)phthalate	3.2	1 of 2
p-dichloro-m-cresol	1.8	1 of 2
diethylphthalate	31	1 of 2
di-n-butylphthalate	4.4	1 of 2
In Secondary Stack Gas:	**ng/m3**	**No. times detected**
benzoic acid	8.5	3 of 3
bis(2-ethylhexyl)phthalate	2.1	2 of 3
di-n-butylphthalate	9.3	3 of 3

Note: Detection limits mostly between 1.0 and 0.2 ppm

METAL CONCENTRATION IN PROCESS STREAMS AT PEAK OIL

Metal	Soil Feed	Stack Flue Gas	Scrubber Effluent	Scrubber Solids	Furnace Ash
	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
As	2.8	37	0.085	70	3.4
Ba	520	810	0.16	370	775
Cd	4.2	1700	0.009	135	4.2
Cr	23	275	0.08	300	27
Cu	50	375	0.04	350	66
Pb	5270	580,000	0.21	90,000	6500
Ni	8.3	38	0.04	78	10
V	9.0	19	0.02	38	13
Zn	1080	8500	0.90	18,000	1090

Data in this table based on three separate runs.

METAL CONCENTRATION IN PROCESS STREAMS AT ROSE TOWNSHIP

Metal	Soil Feed	Primary Flue Gas	Secondary Flue Gas	Scrubber Water	Furnace Ash
	(ppm)	(ppm)	(ppm)*	(ppm)	(ppm)
As	11	94	78 (1%)	0.065	15
Ba	705	3100	782 (0%)	1.5	1172
Cd	8	529	1309 (3%)	0.068	5.8
Cr	114	478	3110 (9%)	0.055	87
Cu	20	110	431 (5%)	0.11	16
Pb	1550	5490	15,130 (4%)	1.43	870
Ni	26	215	480 (3%)	0.28	36
V	21	45	503 (16%)	0.12	29
Zn	280	1550	3000 (3%)	0.58	350
Flow	150 lb/hr	0.093 lb/hr	0.0013 lb/hr	15 gal/hr	--- ---

*: numbers in parenthesis indicate percentage of carryover from primary to secondary flue gas.
Data in this table based on three separate runs.
Not enough scrubber solids to allow for analysis.

RESULTS OF DIOXIN/FURAN ANALYSIS AT PEAK OIL

PCDD/PCDF in Soil	PCDD/PCDF in Scrubber	PCDD/PCDF in Flue Gas	PCDD/PCDF in Ash
(ppb)*	(ppb)*	(ppb)*	(ug/m3)+
ND	ND	ND	ND
ND	ND	ND	0.47
ND	ND	ND	ND

*: approximate detection limit, 1 ppb.
+: approximate detection limit, 1 ug/m3.
Notes:
Analysis by EPA Method 8280, SW-846.
Samples analyzed for tetra- to octa-chlorodibenzodioxin and chlorodibenzofuran.

DIOXIN/FURAN RESULTS AT ROSE TOWNSHIP

PCDD/PCDF in Soil	PCDD/PCDF in Scrubber	PCDD/PCDF in Flue Gas	PCDD/PCDF in Ash
[ppb]*	[ppb]*	[ppb]*	[ug/m3]+
0.06	ND	ND	ND
ND	ND	ND	ND
ND	ND	ND	ND
ND	ND	----	ND
0.06	ND	----	ND
ND	ND	----	ND
ND	ND	----	ND
ND	ND	----	ND
ND	ND	----	ND
ND	ND	----	ND
0.08	ND	----	ND
0.10	ND	----	ND
0.06	ND	----	ND
0.07	ND	----	ND
ND	ND	----	ND
0.05	ND	----	0.03
0.06	ND	----	ND

ND: species was not detected.
*: approximate total detection limit, 1 ppb.
+: approximate total detection limit, 1 ug/m3.
Notes:
Only tetrachlorodibenzofuran detected.
Analysis by EPA Method 8280, SW-846.
Samples analyzed for tetra- to octa-chlorodibenzodioxin and chlorodibenzofuran.

AMBIENT PCB CONCENTRATIONS

Congener Class	Peak Oil Site Upwind (ng/m3)	Peak Oil Site Downwind (ng/m3)	Rose Township Site Upwind (ng/m3)	Rose Township Site Downwind (ng/m3)
monochlorobiphenyl	0.30	0.93	0.84	4.30
dichlorobiphenyl	0.10	0.14	0.33	0.40
trichlorobiphenyl	3.07	10.92	2.00	1.73
tetrachlorobiphenyl	3.03	11.11	5.76	8.85
pentachlorobiphenyl	0.62	3.85	0.61	1.56
hexachlorobiphenyl	2.19	8.71	DL	DL
heptachlorobiphenyl	0.08	3.17	DL	DL
octachlorobiphenyl	DL	0.09	DL	DL
nonachlorobiphenyl	DL	DL	DL	DL
decachlorobiphenyl	DL	DL	DL	DL

Peak Oil data represent average of five days.
Rose Township data represent average of nine days.
DL indicates concentration was below analytical detection limit.

TOXICITY CHARACTERISTIC LEACHING PROCEDURE (TCLP) DATA

Metal	Detection Limit (ppm)	Regulatory Limit (ppm)	Rose Township Feed (ppm)	Rose Township Ash (ppm)	Peak Oil Site Feed (ppm)	Peak Oil Site Ash (ppm)
As	0.002	5	DL	DL	0.007	0.007
Ba	0.009	100	1.9	0.80	0.17	0.24
Cd	0.003	1	0.015	0.005	0.036	0.006
Cr	0.009	5	0.063	0.31	0.021	0.038
Pb	0.002	5	0.70	0.46	4.7	0.012
Hg	0.0002	0.2	DL	DL	DL	DL
Se	0.003	1	DL	DL	DL	0.012
Ag	0.009	5	0.015	0.021	0.030	0.050

Data in this table represent average of three sets of samples.
Temperature in primary chamber = 1600°F.

EXTRACTION PROCEDURE (EP) TOXICITY DATA

Metal	Detection Limit (ppm)	Regulatory Limit (ppm)	Rose Township Feed (ppm)	Rose Township Ash (ppm)	Peak Oil Site Feed (ppm)	Peak Oil Site Ash (ppm)
As	0.002	5	DL	DL	0.01	0.02
Ba	0.009	100	0.91	0.79	0.31	1.3
Cd	0.003	1	0.007	0.009	0.10	0.10
Cr	0.009	5	0.045	0.11	0.07	0.065
Pb	0.002	5	0.18	0.11	38	30
Hg	0.0002	0.2	DL	DL	0.0004	0.0017
Se	0.003	1	DL	DL	DL	DL
Ag	0.003	5	0.015	0.013	0.014	0.037

Data in this table represent average of three sets of samples.
Temperature in primary chamber = 1600 F.